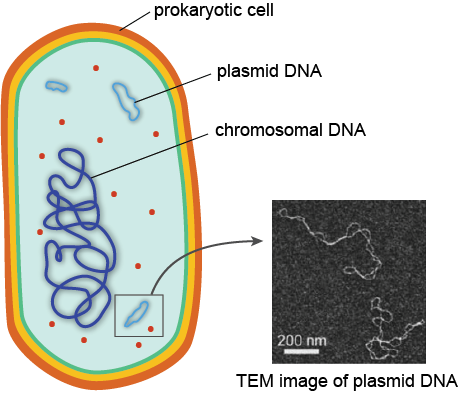
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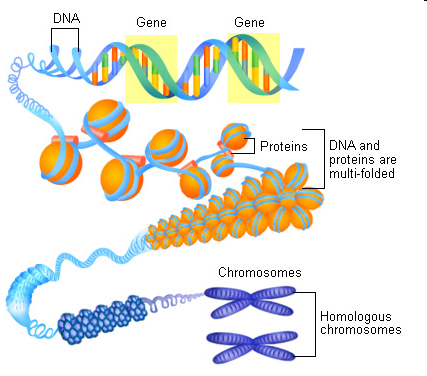
**Unit 6 Notes, Part 1: The Cell Cycle and Mitosis**

Ms. Ottolini, AP Biology, 2012-2013

**Organization of Genetic Material**

1. The cell’s total library of DNA is called its genome.



1. The prokaryotic genome is typically a single, long DNA molecule. In prokaryotic cells, there are also small circles of DNA called plasmids that are separate from the main genome.
2. A eukaryotic genome is much larger than a prokaryotic genome; a human cell generally contains much more DNA than a bacterial cell.
3. **Question:** What must happen to the DNA in a cell before that cell can divide in order to reproduce?
4. In a human cell that is not actively dividing, DNA is typically found as chromatin, a complex of DNA and associated protein molecules called histones.

**Question:** What is the role of the histone proteins?

1. In a human cell that is preparing for division or actively dividing, DNA is found as chromosomes, which are strings of chromatin that are super-coiled.

**Question:** Why does the DNA organize itself this way during cell division?

7) Each side of an X-shaped chromosome is made of an identical copy of DNA called a sister chromatid. During cell division, these copies must be divided to give each daughter cell a full genome (aka genetic library). The chromosomes are connected at a region called the centromere. The proteins in the centromere that are attachment sites for mitotic spindle fibers (chromatid-separating structure used during cell division) are called kinetochores.

1. **Question:** What is the difference between somatic cells and gametes? How many chromosomes are found in human somatic cells vs. gametes?

**The Cell Cycle**

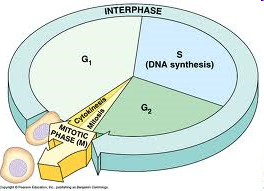
9) The ability to reproduce is one characteristic of living things.

10) Not all cell division helps an organism to reproduce. See below for a list of the functions of cell division in unicellular vs. multicellular organisms.

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| **Unicellular Organisms** | **Multicellular Organisms** |
| * Reproduction only | * Replacing cells that die from normal wear and tear * Growth and development from a single fertilized egg (zygote) * Reproduce asexually (ex: plants can grow by “grafting” / “cutting”) |

11) Steps of the cell cycle (all the events in the life of a cell)

* Interphase comprises 90% of the cell cycle. In this portion of the cell cycle, the cell is not dividing and is going through all its normal activities. During this phase, the DNA is spread out as chromatin, and the nuclear membrane and nucleolus are visible. Interphase is divided into three phases (and sometimes a fourth). These phases are described below.

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**G1 phase** (first gap): the cell grows by producing proteins and organelles. (Note: this is the normal life of the cell!)

**S phase** (synthesis): the cell makes a copy of its DNA

**G2 phase** (second gap): the cell makes molecules / organelles needed for cell division

Ex: centrosomes are copied (these centrosomes contain centrioles in animal cells)

**G0 phase:** cell leaves the normal cell cycle and stops dividing

Ex: liver cells (can reenter the cell cycle if the liver is injured and damaged cells must be replaced); muscle / nerve cells (never divide again once they are mature)

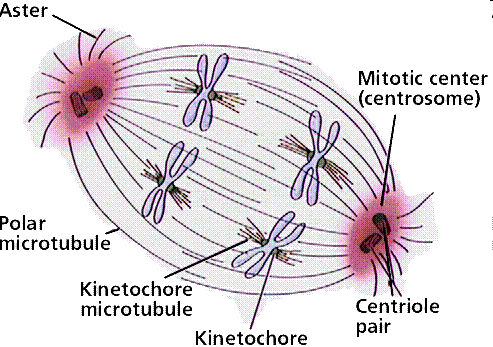
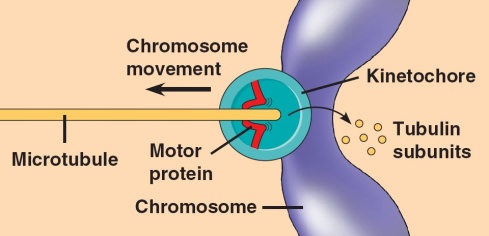
* Interphase is followed by mitosis, the division of a cell’s nucleus and cytokinesis, the division of a cell’s cytoplasm. At the end of the cell cycle, two daughter cells are produced that then enter the cell cycle again.
* A typical human cell divides around every 24 hours.

**M phase** < 1 hour

**S phase** = 10-12 hours

**G1 and G2 phase** = the rest of the time (G1 length varies the most between different cell types… ex: skin cells have shorter cell cycles and shorter a shorter G1 phase than muscle cells)

**Cellular Equipment Needed for Division**

* The mitotic spindle is a structure that forms in the cytoplasm during the beginning stage of mitosis (prophase); it is used to separate sister chromatids during mitosis
* The spindle is assembled from elements of the cytoskeleton called microtubules (made of chains of tubulin proteins). The spindle fibers elongate by adding more tubulin subunits.
* Assembly of microtubule fibers starts in the centrosome, AKA the “microtubule organizing center.” In animal cells, organelles called centrioles are found at the center of the centrosome, but they do not seem to be necessary for spindle formation.
* Possible mechanisms for how the mitotic spindle works:

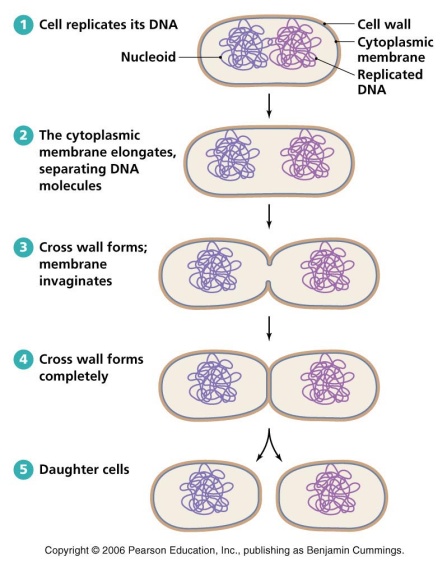
1. Chromosomes are “reeled in” by the shortening of microtubules at the poles

OR

1. Evidence suggests that microtubulesmay shorten at the end holding the chromosome as motor proteins on the kinetochore “walk” chromosomes along microtubules toward the poles / ends of the cell

**The Stages of Mitosis**

|  |  |  |
| --- | --- | --- |
| **Stage Name** | **Description** | **Picture** |
| Prophase | * Chromatin becomes tightly coiled into chromosomes * The nucleolus disappears * Mitotic spindle begins to form… microtubules that extend from the centrosomes creating a structure that looks like a star or “aster” * Centrosomes move toward the poles / ends of the dividing cell. |  |
| Prometaphase | * The nuclear membrane (aka the nuclear envelope) fragments (breaks apart) * Spindle fibers attach to chromosomes at their centromeres using kinetochore proteins * Some spindle fibers do not attach to chromosomes. These are called nonkinetochore fibers or nonkinetochore microtubules. | http://www.edupic.net/Images/Mitosis/prometaphase.png |
| Metaphase | * Longest dividing phase * Spindle fibers push chromosomes to line up along an imaginary plane at the equator (center of the cell) called the metaphase plate. |  |
| Anaphase | * Shortest dividing phase * Sister chromatids separate and move to opposite poles of the cell. Once the chromatids separate, each chromatid is considered a daughter chromosome. |  |
| Telophase | * AKA “reverse prophase” * Two daughter nucleoli begin to reform * Nuclear envelope reforms * Chromosomes spread out as chromatin * Spindle / centrosomes disappear |  |
| Cytokinesis | * Cytoplasm splits * Usually starts in late telophase * The cleavage furrow splits animal cells (actin and myosin proteins interact to contract a ring around the membrane) **(see note on actin and myosin proteins on the next page!)** * The cell plate splits plant cells (cell wall materials are deposited by vesicles from the Golgi) |  |

**Evolution of Mitosis**

* Mitosis may have had its origins in binary fission, a method used by bacteria to reproduce
* In binary fission…

1. Bacteria have a large circular chromosome
2. Replication of DNA (before division) starts at one point, the origin of replication and moves in both directions
3. The cell elongates
4. The plasma membrane (aka cell membrane) grows inward
5. The cell is divided into two daughter cells, each with a complete genome
6. No spindle or microtubules are involved in this process, but several proteins play a role in this process (you do not need to know their names, but know that they are related to tubulin and actin—two cytoskeleton proteins—and they are similar to eukaryotic proteins…hence the connection between binary fission and mitosis!

***\*\*\*Note on actin and myosin proteins used in the formation of a cleavage furrow during animal cell cytokinesis:*** *Actin and myosin are two proteins that are also used in muscle cell contraction in humans. Myosin has small “heads” that can attach to actin and pull it, just like human hands pull a rope in a tug-of-war competition. This causes the muscle cell to shorten and contract. The interaction between actin and myosin also causes the plasma membrane at the center of a dividing cell to contract / pinch, forming the cleavage furrow.*

